PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
PDGW/UCL/316		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB 03/05428	12.12.2003	13.12.2002
International Patent Classification (IPC) or both national classification and IPC		
H04B10/13		
Applicant		
UNIVERSITY COLLEGE LONDON et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 3 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the opinion
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
08.07.2004	19.05.2005
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Shaalan, M Telephone No. +49 89 2399-7723

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB 03/05428

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, Pages

1, 2, 4-10	as originally filed
3	received on 10.05.2005 with letter of 10.05.2005

Claims, Numbers

1-9	received on 10.05.2005 with letter of 10.05.2005

Drawings, Sheets

1/3-3/3	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).

   ☐ the language of publication of the international application (under Rule 48.3(b)).

   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority in written form.

   ☐ furnished subsequently to this Authority in computer readable form.

   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:

   ☐ the claims, Nos.:

   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-9
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-9
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-9
	No:	Claims	

2. Citations and explanations

   see separate sheet

Re Item V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Document D2, see in particular the passages cited in the search report, discloses as in claim 6 (the references in parenthesis apply to the figures of D2):

a radio frequency (column 9, lines 6-8) optical communication system (figure 9) having a multimode optical fibre (figure 10, item 1),

- at least one single transverse mode (column 8, lines 48-49) laser transmitter (figure 9: 1) in use providing optical radiation;
- means of coupling (5) optical radiation from the at least one single transverse mode laser transmitter (1) into a multimode fibre (6) using a launch which restricts the number of modes excited in the fibre (column 8, lines 38-43); and
- a photodetector (9);
- a device for demodulating the output of the photodiode (9)

2.1 The subject-matter of the claim therefore differs from this known radio frequency optical communication system in that:
the radio frequency modulated optical signals are **32-QAM** signals.

The problem to be solved by the present invention may therefore be regarded as to modify the radio frequency optical communication system known from D2 in order to "reduce the susceptibility of signal loss due to transmission nulls."

2.2 The combination of the features of claim 6 is neither known from, nor rendered obvious by, the available prior art. The reasons being as follows:

Due to the problems in connection with an off axis launch, a skilled person would not combine the **32-QAM** radio frequency transmission, which is known from D1, with the offset launch (known from D2), which discloses a radio frequency transmission only in a binary form.

3. The subject-matter of independent claim 1 corresponds to that of claim 6. Therefore, the claim is novel and inventive following Article 33 PCT.

Certain defects in the international application

1. The description should be adapted to the amended claims.

Centre launch, where the optical power from the signal transmitter is coupled into the central (low order) fibre modes using standard connectors and uniters, works very well for many fibres. However a significant proportion of the installed fibre base has very poor performance when used with centre launch, caused by imperfections in the refractive index profile of the fibre core.

It is known that offset launch, where the optical power is coupled into the higher order modes away from the fibre centre, can be used for successful baseband digital transmission in virtually all multimode fibres. This can be achieved using laser sources rather than the more conventional LEDs used in datacommunications systems, as exemplified by the published PCT patent specification no. WO97/3390 entitled 'MULTIMODE COMMUNICATIONS SYSTEMS (HEWLETT PACKARD COMPANY). In the above-mentioned work, offset launch is used to guarantee the specified (over-filled launch) bandwidth by enhancing the performance of some fibres that would otherwise have low bandwidth using conventional launch conditions.

This, however, aims to guarantee bandwidth of multimode fibre for high data transmission rate digital baseband signal based systems (eg. Gigabit Ethernet).

Furthermore, Wake et al showed recently (in Electronics Letters, vol.37, pp. 1087-1089, 2001) that it was possible to transmit radio frequency signals over multimode fibre by operating at frequencies in the flat-band region beyond the 3dB bandwidth of the fibre. This work opened up the possibility that a new type of radio over fibre transmission link was feasible, but stopped short from offering a stable and robust approach to the problem.

The present invention goes beyond both of these examples of prior art; the aim is not to guarantee fibre bandwidth but to ensure that signal transmission over the fibre occurs in a stable operating regime (for both amplitude and phase) not necessarily restricted to the fibre baseband bandwidth. The Wake prior art only

CLAIMS

1. A method of reducing the susceptibility of signal loss due to transmission nulls in an optical signal transmission system using a multimode optical fibre (19), at least one single transverse mode laser transmitter (13) providing radio-frequency-modulated optical signals for said multimode fibre (19), and a photodetector (20), the method comprising coupling said signals into the multimode optical fibre using a launch (18) which is collinear with an axis of the multimode optical fibre and offset from the fibre axis, characterised in that the radio-frequency-modulated optical signals are 32-QAM signals.

2. The method of claim 1, wherein the launch (18) is achieved by one of the group comprising a launch from a single transverse mode laser with a single mode fibre pigtail into a graded-index multimode fibre using a mode- conditioning patchcord and a launch from a laser receptacle package into a graded-index multimode fibre where the axis of the optical output from a single transverse mode laser has been offset from that of the fibre.

3. The method of claim 1, wherein the multimode fibre has a core diameter of 62.5μm and wherein the coupling step comprises using a launch having offset distance measured from the centre of the multimode fibre core to the centre of the optical radiation emitted from the transmitter is from approximately 10μm to approximately 30μm.

4. The method of claim 3, where the offset distance measured from the centre of the multimode fibre core to the centre of the optical radiation emitted from the transmitter is from approximately 23μm to approximately 30μm.

5. The method of any preceding claim wherein the multimode fibre is one or more of the group comprising old fibre that has been installed within buildings; new fibre; silica fibre; plastic fibre; fibre with multiples splices and/or connectors ; fibre with low specified bandwidth; and fibre with high specified bandwidth.

6. A radio frequency optical communication system having

a multimode optical fibre (19),

at least one single transverse mode laser transmitter (13) having an output

a signal input means for causing the single transverse mode laser transmitter to provide radio-frequency-modulated optical signals for said multimode fibre;

means of coupling said optical signals from the or each single transverse mode laser transmitter into the multimode fibre using a launch (18) which restricts the number of modes excited in the fibre;

a photodetector (20); and

a device (22) for demodulating the output of the photodetector (20), characterised in that the radio-frequency-modulated optical signals are 32-QAM signals.

7. A radio frequency optical communication system according to claim 6, where the means of coupling light into the fibre produces a launch which is co-linear but at an offset to the fibre axis.

8. A radio frequency optical communication system according to claim 7, where the fibre (14) has a core diameter of 62.5μm and where the offset distance measured from the centre of the multimode fibre core to the centre of the optical radiation emitted from the transmitter (13) is from approximately 10μm to approximately 30μm.

9. A radio frequency optical communication system according to claim 8, where the offset distance measured from the centre of the multimode fibre core to the centre of the optical radiation emitted from the transmitter is from approximately 23μm to approximately 30μm.